IS ONLY CR THOROUGHLY ANOMALOUS IN CARBONACEOUS CHONDRITES? F. A. Podosek[1], R. H. Nichols[1], J. C. Brannon[1] and U. Ott[2]. 1. McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, USA. 2. Max-Planck-Institut fur Chemie, D-55128 Mainz, FRG.

In CI and CM meteorites essentially all the Cr is isotopically anomalous. Stepwise dissolution of whole rock samples reveals consistent patterns of both deficiencies and excesses of ^{54}Cr. We have examined the isotopic compositions of K, Ca, Fe, Rb and Sr in samples of Orgueil previously analyzed for Cr. These elements may exhibit anomalies, notably a few permil excess of ^{40}K in one dissolution fraction, but there is no pattern of anomalies as large and pervasive as those in Cr. It remains unclear why Cr should be so distinctive.

CI meteorites such as Orgueil and CM meteorites such as Murchison contain isotopically anomalous Cr [1-2] in a pattern that is thus far unique. Stepwise dissolution of *whole rock* samples in a series of different reagents liberates Cr which is anomalous in every fraction: Phases dissolving in acetic and nitric acids have deficits of ^{54}Cr, whereas the residues, dissolved in hydrochloric, hydrofluoric, *etc.*, acids, have excesses of ^{54}Cr (up to 210 ε-units). To the extent constrained by the few mass balances available, the deficits and excesses cancel, *i.e.* whole rock compositions are at least approximately normal. This suggests that the anomalies are complementary, *i.e.* that these meteorites incorporate diverse nucleosynthetic sources of Cr in normal proportions but that these sources have never been completely mixed. At least in Orgueil it appears plausible that perhaps only one phase contains Cr with excess ^{54}Cr and that other phases contain homogenized Cr which would be normal except for lack of the ^{54}Cr-rich component [2].

Thus far there are no known anomalies in other elements which correlate with those in Cr. Since it can be expected that whatever phase carries the anomalously heavy Cr is likely to have anomalies in other elements as well, it appears probable that the carrier phase is relatively rich in Cr, so that anomalies in other elements are more diluted in the experimental procedures thus far employed. The nature of the carrier is otherwise constrained only by its chemical behavior in the dissolution experiments and the likelihood that it has reacted with its surroundings during the relatively mild metamorphism experienced by CO and CV meteorites [1]. It is suspected but not known that the carrier is a presolar solid phase which has been preserved in these primitive meteorites; if so, its isotopic composition is probably much more radically anomalous than anything yet observed in dissolution experiments (*cf.* [3]). There is no dearth of Cr-rich phases observed in Orgueil [2,4], but so far there is no association between mineralogy and isotopic structure. Indeed, if the hypothesized carrier is a radically anomalous presolar phase it could easily have escaped detection to date [2].

To further explore the nature of this effect we have examined (by thermal ionization mass spectrometry) the isotopic compositions of other elements in the same dissolution fractions previously analyzed for Cr [2,5]: Fe in Orgueil IV and K, Ca, Rb and Sr in Orgueil I. In part the motivation is as noted above: Whatever phase carries a ^{54}Cr-rich component is likely to be anomalous in its other elements as well, and at present we have but poor constraints on its identity. More generally, however, there is as yet no rationale for why the element Cr, or its postulated anomalous host phase, should be singled out. If the observed isotopic effects are attributable to a preserved interstellar phase, for example, this phase evidently lacks the chemical and thermal refractoriness which are precisely the features which permit the isolation and detailed laboratory study of known types of interstellar grains. Such a phase would be more representative of interstellar solids generally, and if it has survived, why not others as well? The same logic applies if the postulated host is not interstellar but rather the result of nebular processing of a modestly nonrepresentative mix of presolar precursors, *e.g.* as is believed to be the case for CAIs. Unlike CAIs the Cr-bearing phase is evidently not particularly refractory, nor otherwise distinctive in any way yet known, so if it was thus produced and preserved, why not others?

In the Fe analyses ^{54}Fe/^{56}Fe was used for normalization. No anomalies were observed within error limits of about 5 ε for ^{57}Fe and 15 ε for ^{58}Fe. The most plausible nucleosynthetic source for a ^{54}Cr-rich component is neutron-rich nuclear statistical equilibrium, so that co-produced Fe provides the most direct quantification of the inference that the heavy-Cr carrier must be Cr-rich: If it is assumed that ^{54}Cr and ^{58}Fe were produced in approximately solar ratio, absence of a ^{58}Fe anomaly indicates that the postulated host phase must have Cr/Fe at least twenty times the solar value.

There is suggestive evidence for anomalous K in Orgueil [6]. ^{41}K/^{39}K is normal within limits imposed by uncertainty in instrumental discrimination (about 1%), but one fraction (not the one with the biggest ^{54}Cr effect) has an apparent 35-40 ε excess of ^{40}K. The excess is statistically well resolved and is not attributable to cosmic-ray-induced nuclear reactions, but remains only suggestive pending evaluation of possible interferences in the spectrometric analysis [6].

Rb has only two isotopes, so that small nuclear effects cannot be distinguished from variations in instrumental discrimination. Observed ^{87}Rb/^{85}Rb ratios are indistinguishable from terrestrial normal within about 0.5%.

In Sr analysis ^{88}Sr/^{86}Sr is used for normalization; we observed no variations larger than those attributable to discrimination, *i.e.* this ratio is also normal within about 0.5%. Possible nucleosynthetic anomalies at ^{87}Sr cannot be distinguished from variable additions of the radiogenic contribution from ^{87}Rb. There are no well-resolved anomalies at ^{84}Sr beyond experimental limits that vary from 2 to 10 ε depending on available sample.

In Ca analysis $^{44}Ca/^{40}Ca$ is used for normalization; we observed no variations beyond those attributable to discrimination, about a few percent. For the other isotopes analytical error limits vary according to sample size. No fraction shows evidence for anomalies in ^{42}Ca (1 to 10 ε-units), ^{43}Ca (3 to 20 ε-units) or ^{46}Ca (10 to 100 ε-units). Most fractions also have normal ^{48}Ca (1 to 10 ε-units); one or two show evidence for small ^{48}Ca excesses, but the effects are not well resolved (3 to 4 sigma) and are hardly more than marginal.

All available data considered, there is evidence that stepwise dissolution reveals isotopic heterogeneity in Orgueil in other elements besides Cr. This evidence is suggestive but not yet compelling, and deserves further attention. Equally or more deserving of attention is the absence of anomalies comparable in magnitude and ubiquity to those in Cr. If this feature persists it will provide an argument that, contrary to reasonable expectation, the element Cr or one of its host phases in carbonaceous chondrites is special in some way not yet recognized.

We have also begun a comparable study of the CM chondrite Murchison. The Cr results are similar to prior observations [1] in indicating a consistent pattern similar to but distinct from that in Orgueil. The acetic and nitric acid fractions have more variable and greater ^{54}Cr deficits (to -15 ε) and the subsequent fractions contain more Cr with smaller ^{54}Cr excesses (to +15 ε). The basic character of the effect is evidently fundamentally the same in CI and CM meteorites, with the differences in the details probably arising in different parent body histories.

References: [1] Rotaru *et al.* (1992) Nature 358, 465. [2] Podosek *et al.* (1997) MAPS, submitted. [3] Ott *et al.* (1997) LPSC XXVIII (this volume). [4] Greshake & Bischoff (1996) LPSC XXVII, 461. [5] Podosek *et al.* (1996) MAPS 31, A109. [6] Podosek *et al.* (1997) LPSC XXVIII (this volume).